Community of Mesostigmata (Acari) in experimental habitat patches of forest floor

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Abstract

The aim of the study was to test whether populations and communities of predatory microarthropods (Mesostigmata) are differentiated between different habitat patches of the forest floor, whether there are migrations between patches according to time of day or prevailing weather, and what is the large-scale ("global") heterogeneity of the community. Artificial patches were created by removing dwarf shrubs and herbs from test plots, and introducing coniferous or deciduous litter, faecal material or rotten wood. Samples (0-3 cm) were taken in summer and autumn in dry and moist conditions. The communities of different patches were significantly different. Several species were more numerous in the faecal treatment, though few "dung specialists" were present. Some species showed affinity to plots with additional litter, but communities from spruce and birch litter treatments did not differ from each other in total composition. There was little difference between seasons. The data give evidence of horizontal movements between patches depending on moisture. Population densities of several species differed significantly between blocks inside the 0.5 ha study area, but the average total community was similar to that in another forest 70 km north of this.

Keywords: Mesostigmata, forest soil, litter, heterogeneity, patchy habitat.

Communautés de Mésostigmates (Acari) dans des habitats expérimentaux hétérogènes sur sol forestier

Résumé

Le but de cette étude était de mettre en évidence les différences entre les populations et les peuplements de microarthropodes prédateurs (Mesostigmata) selon leur habitat dans un sol et une litière forestière, d'évaluer les échanges d'individus entre les patchs durant le jour ou selon l'humidité, et d'évaluer l'hétérogénéité à grande échelle (« globale ») de la communauté. Des patchs artificiels ont été créés en éliminant les brindilles et les herbes des parcelles expérimentales, et en introduisant de la litière de conifères ou de caducifoliés, des matières fécales ou du bois pourri. Deux séries d'échantillons (0-3 cm) ont été prélevées, en été et à l'automne, respectivement en condition de sécheresse et de plus grande humidité. Les communautés différaient significativement entre les patchs. Plusieurs espèces se révélèrent plus abondantes dans le traitement « matières fécales », bien qu'il y ait peu d'espèces spécialistes du fumier. Certaines espèces manifestèrent de l'affinité pour la litière ajoutée, sans qu'il y ait de différences entre la litière de bouleau et celle de sapin. Peu de différences entre les saisons ont pu être observées. Les résultats mettent en évidence des migrations horizontales entre les patchs sous la dépendance de leur humidité. Les densités des populations de certaines espèces étaient significativement différentes entre les parcelles expérimentales à l'intérieur de l'aire d'étude d'environ 0.5 ha, mais à l'échelle du peuplement global, ces effectifs étaient très similaires à ceux observés dans une autre forêt, située 70 km plus au nord.

Mots-clés : Mésostigmates, sol forestier, litière, hétérogénéité, habitat en patchs.

INTRODUCTION

Patch dynamics of populations and communities are among the most important topics in ecological research. Habitat patchiness is probably one of the main factors that maintain diversity in natural communities (Begon *et al.*,1990). Anderson (1978) has observed a positive correlation between microhabitat diversity and species diversity in oribatids in deciduous forest soil.

Aggregated distribution of populations is a rule rather than an exception in nature. However the relation of aggregations to environmental variables is often obscure. Usher (1976) has analysed the population distribution in microarthropods, and observed three different types of aggregations in relation to population density. These in turn can be related with microclimatic conditions and food availability. Mesostigmata show less tendency to aggregations than oribatids and collembolans (Usher, 1976). The size of aggregations also depends on size and population density of species; Usher has distinguished between "aggregates" and large-scale "gradients".

Forest floor is a mosaic of habitat patches in different scales. In this mosaic, both primary resources and physical conditions form an unlimited number of combinations, also changing in time when resources become utilized and fresh ones appear. Accordingly, populations are likely to migrate vertically and horizontally in search of food, shelter and sites for reproduction. Hågvar and Kjöndal (1981) have shown that some Collembola that are only occasionally found in soil samples may be gathered in litter bags with decomposing birch leaves. Joosse (1981) has shown that species of Collembola share their habitat horizontally on the basis of microclimatic conditions.

Mesostigmatid mites are mainly generalist predators, though some are more or less specialised on nematodes or collembolans (Karg, 1983, 1986, 1993). Thus they are not directly dependent on certain substrates as food, and quality of primary resources (coniferous, deciduous, wood etc.) is not likely to regulate populations. But the amount and nature of their prey depend on microbial production and activity. Physical structure of the substrate also modifies the microclimate, and determines the space for moving and reproduction. Large predatory species that move actively in search of food can be expected to migrate between microhabitats according to circumstances.

The aim of this study was to find out:

1. Do mesostigmatid species and populations show affinity to certain kinds of patches in the forest floor, and/or are different patches characterized by certain communities of predatory mites.

2. Are there horizontal migrations between patches in a scale of m^2 according to time of day or prevailing weather.

3. How constant is the community in a larger scale (< 100 m up to 100 km).

Because natural patches are hard to define and delimit, the approach adopted in the study was to experimentally "enrich" test plots in a forest with different constituents of the forest floor (coniferous and deciduous litter, faecal matter, rotten wood), using a randomized block design in a moderately large area (0.5 ha), and to take sets of samples in dry and moist conditions in two seasons.

MATERIAL AND METHODS

The study site is an old mixed stand of norway spruce, scots pine and silver birch, 30 km SW of Jyväskylä, central Finland. *Vaccinium myrtillus* is the dominant plant species in the field layer vegetation. The soil is a podzol with raw humus (pH 4.1), covered by an almost continuous carpet of common forest mosses.

Five plots of 135 × 180 cm were measured in homogeneous places in an area of ca. 0.5 ha. They were divided into six 60 × 50 cm subplots, separated by 15 cm corridors of intact ground. On 18 May 1994 these subplots received randomly one of the following treatments:

1. *Intact* (control).

2. *Cut.* Removal of dwarf-shrubs and herbs, leaving the moss carpet on soil intact.

3. *Conif.* Spruce needle litter, shaken from branches of trees that were felled during winter, 1.5 kg (d.m.) m^{-2}.

4. *Decid.* Birch leaf litter, overwintered under snow, 1.15 kg (d.m.) m^{-2}. The plots were covered with a coarse net to prevent dispersion of the litter.

5. *Faec.* Horse droppings, to represent faecal material, 2 kg (d.m.) m^{-2}.

6. *Wood.* Two 60 cm pieces of rotten conifer trunks (in an advanced state of decay and covered by a humified layer and mosses, lying on ground at the study site), were placed on the test plots side by side, after removing the original organic soil layer.

Dwarf shrubs and herbs were also cut before litter addition from treatments 3 to 5, and the materials were defaunated by freezing (–27°C) before use.

Sampling was carried out in summer during a dry spell (28 July 1994 at 13.00-15.00 p.m.) and after a few rainy days (2 Aug. at 9.00-11.00), and in autumn during afternoon (21 Sept. at 14.30-16.00) and morning (22 Sept. at 7.30-9.00). Temperatures were recorded and water contents of the soil organic layer were determined at the time of sampling (*table* 1). The samples were taken with a cylindrical steel corer, cutting area 25 cm^2, inside which plastic rings were inserted. After removing the rings with the soil core, the topmost soil was slightly compressed to fill one ring (3 cm), which was cut off and

Table 1. – Water contents of the organic layer (% of fresh mass, ± S.D.), and temperatures of air, litter and humus (in the middle of the ca. 4 cm deep layer) at the time of samplings.

	Moisture	Temperature °C		
		Air	Litter	Humus
28 July, dry weather	45.4 ± 5.6	29	26	17
2 Aug., wet weather	55.4 ± 3.1	18	17	15
21 Sept., afternoon ("Dry")	69.3 ± 4.1	10	10	10
22 Sept., morning ("Wet")	63.0 ± 2.5	0.5	2	6

transported into the laboratory for extraction. One core from each block and treatment was taken at each sampling (total area/treatment 125 cm^2 at each of the 4 occasions). The samples from the "Wood" treatment hardly included the wood itself; therefore the next 3 cm layer was also taken. Microarthropods were extracted using a modified high gradient canister extractor (Macfadyen, 1961), applying the "medium" temperature regime by Leinaas (1978). Mesostigmatid mites were picked under a dissecting microscope and identified under a microscope using the keys of Evans and Till (1979) and Karg (1989, 1993).

The data were analysed after logarithmic transformation using ANOVA with the randomized block design. This was done separately for summer and autumn samples, because the "weather" factor was not comparable in the two seasons. In addition, differences between seasons were tested with simple ANOVA, ignoring the block effect. Canonical correspondence analysis (CCA) was performed using the canonical community ordination programme (Ter Braak, 1987) in order to ordinate the species with treatments and sampling time. Rare species were excluded from the analysis.

RESULTS AND DISCUSSION

Community structure

A total of 4686 specimens of Mesostigmata were counted, belonging to 32 species. Four of these have not been previously recorded from Finland. The average total density was 15600 m^{-2}, wich is comparable with earlier studies (Huhta and Koskenniemi, 1975; Huhta *et al.*, 1986; note that only the topmost 3 cm was sampled). The community structure was very similar to that in a spuce forest ca. 70 km N of this (Huhta *et al.*, 1986). Five most abundant species were the same and in the same order at both sites (*Parazercon radiatus, Veigaia nemorensis, Trachytes minima, T. aegrota* and *Lysigamasus lapponicus*; *table* 2). Even a dry pine forest in southern Finland shows a considerable resemblance to the present site, while in another pine stand near the southern coast *L. lapponicus* is replaced by *L. parrunciger* (Huhta *et al.*, 1986) This shows that the mesostigmatid community in coniferous forests is remarkably constant in composition.

Treatment effects

The treatment effect was significant in 11 species, either in summer or autumn samples, or both (*table* 2).

No species showed significant preference to the "Cut" plots without litter additions. This is in accordance with the experiment of Ponge *et al.* (1993): cutting of the herbaceous layer in a temperate deciduous forest had no effect on Collembola. It is obvious that physical and nutritional conditions on the soil surface under a forest do not essentially change when the rather sparse vegetation (mainly *Vaccinium*) is removed.

There were some significant differences between intact control and the plots with additional litter. *Proctolaelaps* sp. was more numerous in coniferous litter, *L. lawrencei, L. lapponicus* and *U. tecta* in deciduous litter, and *E. ostrinus* in both. Karg (1967) has shown a strong reduction in abundances and species number of Mesostigmata and other mites after removal of litter in a beech forest. Several litter-dwelling species disappeared totally from the test plots during the three-year experiment. He atttributed this to the absence of isolating and protecting litter layer. Ponge *et al.* (1993) observed no impact on Collembola, when the amount of litter in a deciduous forest was doubled, whereas total removal of the annual litter fall decimated the populations of most epigeic species. These three studies are not strictly comparable, however, since the present study site had a thick layer of mosses covering the soil, while removal of litter at the sites of Karg and Ponge et al. left a bare soil surface with little food and shelter for animals. As mainly unspecialised predators, mesostigmatid mites are not dependent on organic debris as food; thus the addition of litter affects only indirectly via improved microclimate, three-dimensional living space and general activity of the decomposer system.

The total density of mesostigmatids was highest in the faecal treatment, where 8 species were more numerous than on intact plots (*table* 2). These include one species known to occur in decaying materials: *A. cetratus* (Huhta *et al.*, 1979), but also species common all over in forest soil: *E. ostrinus, P. kochi, L. lapponicus* (Huhta *et al.*, 1986). *S. baloghi* was found by Koskenniemi and Huhta (1986) (with the name *Dinychella asperata* Berl.) in urea-fertilized plots where mosses had died and partly decayed. In qualitative samples taken two weeks after establishment of the plots, introduction of horse droppings appeared to have decimated the indigeneous populations, but no invasion of "alien" species was observed: all specimes found were common forest species. This indicates that there is no specialized

Table 2. – Total counts of Mesostigmata by treatments. Sample area = 500 cm^2/treatment. P values show significant differences between treatments separately for summer and autumn (¤, ¤¤ = significant treatment x "weather" interactions at $P < 0.05$ and < 0.01). Asterisks before numbers indicate significant ($P < 0.05$) differences from "Intact" in either season.

	Intact	Cut	Conif.	Decid.	Faec.	Wood	Total	P (sum.)	P (aut.)
Iphidosoma physogastris Karg [1]	1	1	0	1	2	3	8		
Eviphis ostrinus (C. L. Koch)	8	1	*23	*55	*72	6	165	< 0.01	< 0.01
Geholaspis longisetosus (Kramer)	3	0	1	2	*10	4	20		< 0.01
Hypoaspis aculeifer (Can.)	1	3	1	1	0	0	6		
Proctolaelaps robustus Evans	0	0	2	1	0	0	3		
Proctolaelaps sp.	0	0	*15	0	0	0	15		0.01
Lasioseius lawrencei Evans [1]	8	4	12	*18	2	0	44	< 0.01	
Iphidozercon gibbus (Berl.)	0	0	0	0	*7	0	7	¤0.03	
Arctoseius semiscissus (Berl.) [1]	0	0	3	0	0	0	3		
A. cetratus (Sellnick)	0	0	0	0	*21	0	21	0.03	¤¤ < 0.01
A. venustulus (Berl.) [1]	0	2	0	0	0	0	2		
Gamasellodes bicolor (Berl.)	0	0	1	1	0	0	2		
Saprosecans baloghi Karg	0	0	1	0	*27	0	28		
Epicrius reticulatus (Grube)	5	3	0	2	0	6	16		
Parazercon radiatus (Berl.)	152	188	106	141	*104	138	829		
Prozercon kochi Sellnick	23	18	21	*34	*52	77	225	0.05	
P. "serlachii" [2]	11	8	7	8	10	0	44		
Punctodendrolaelaps rotundus (Hirschm.)	40	73	35	36	99	6	289		
Dendrolaelaps sp.	0	0	0	0	2	0	2		
Pergamasus brevicornis Berl.	11	5	14	10	5	16	61	¤¤	
Lysigamasus lapponicus (Trägårdh)	40	48	57	*82	*109	26	362		< 0.01
Vulgarogamasus kraepelini (Berl.)	12	13	11	24	*20	3	83		¤¤ < 0.01
Veigaia kochi (Trägårdh)	8	13	2	3	4	9	39		
V. nemorensis (C. L. Koch)	112	128	128	109	165	118	760	¤	
V. exigua (Berl.)	0	0	0	0	1	5	6		
V. cerva (Kramer)	5	1	8	3	8	6	31		
Trachytes aegrota (C. L. Koch)	72	48	58	60	134	48	420		
T. minima Trägårdh	80	115	76	83	69	54	477		
Ipiduropoda dialveolata (Hirschm. & Z.-N.)	4	2	1	0	0	1	8		
Dinychus arcuatus (Trägårdh)	4	0	1	0	*13	21	39		0.02
D. perforatus Kramer	8	0	4	5	22	5	44		
Urodiaspis tecta (Kramer)	19	13	24	*46	*28	6	136		< 0.01
Indet. larvae and nymphs	81	76	55	113	92	74	491		
Total	708	763	667	838	1078	632	4686		
Species	22	20	25	22	24	20	32		

[1] Not previously recorded from Finland.

[2] Undescribed species, same as in Huhta *et al.* (1986).

"dung community" (*cf.* Huhta *et al.*, 1979) inside a forest. One species was less abundant in the faecal treatment than in control: *P. radiatus.*

The total numbers of mesostigmatids were lowest in the "Wood" plots. The only species with a significantly higher population than in the control was *Prozercon kochi.* In the wood itself the numbers of mites were very low (not shown in *table* 2), only 5 to 10% of those in the "surface" samples, and no special wood-dwelling species was found. The "soil" in this treatment can be regarded as an impoverished forest floor, characterised by lack of roots and higher vegetation, with rather inert rotten wood under mosses and thin humus. This can hardly be compared with decaying wood exposed to surface-dwellers. Setälä and Marshall (1994) have reported a diverse community of Collembola in decaying Douglas fir stumps.

Season, weather, and block effects

Few significant differences were detected between the summer and autumn samples (*table* 3). *P. brevicornis* and *V. kochi* were more numerous in summer, and *U. tecta* in autumn. In summer there were no differences in average numbers between dry and wet days, but in September several species were more abundant in early morning ("Wet") than in the afternoon ("Dry"). This was probably caused by vertical migration from deeper humus layers (which is outside the scope of this study). However, inspection of the data also reveals evidence of movements between the patches (significant treatment × weather interactions; *table* 2). In summer, *P. brevicornis* (large, actively moving species) was mainly found in the litter plots on dry weather (1.6 ± 1.5 (S.D.)) specimens/core

Table 3. – Total counts of common species by "Season" (summer, autumn) and "Weather" (autumn only). Sample area = 1500 cm^2/season, 750 cm^2/"weather". Asterisks before numbers indicate significant (P < 0.05) block effects.

	Summer	Autumn	P	"Dry"	"Wet"	P
Eviphis ostrinus	79	86		33	53	0.02
Geholaspis longisetosus	8	12		4	8	
Proctolaelaps sp.	0	15		3	12	
Lasioseius lawrencei	*13	*31		14	17	
Iphidozercon gibbus	2	5		0	5	
A. cetratus	9	12		0	12	0.03
Saprosecans baloghi	0	28		3	25	
Epicrius reticulatus	6	10		5	5	
Parazercon radiatus	377	*452		160	292	< 0.01
Prozercon kochi	79	146		76	70	
P. "serlachii"	*27	*17		6	11	
Punctodendrolaelaps rotundus	*123	*166		76	90	
Pergamasus brevicornis	43	18	< 0.01	8	10	
Lysigamasus lapponicus	204	158		91	67	
Vulgarogamasus kraepelini	33	50		26	24	
Veigaia kochi	28	11	0.02	1	10	0.03
V. nemorensis	334	426		191	235	
V. cerva	12	19		8	11	
Trachytes aegrota	*208	*212		118	94	
T. minima	*238	*239		82	157	
Dinychus arcuatus	*18	21		9	12	
D. perforatus	9	*35		3	32	0.01
Urodiaspis tecta	39	97	< 0.01	57	40	
Indet. larvae and nymphs	245	246		102	144	
Total	2153	2533		1081	1452	0.03
Species	27	30		24	28	

in "Conif", 1.4±0.5 in "Decid", none in "Wood"), and in "Wood" plots on wet weather ("Conif" 0.4±0.5, "Decid" 0.4±0.5, "Wood" 2.2±1.8). In September, *V. kraepelini* (another active species) was gathered in deciduous litter in the afternoon ("Decid" 2.6±1.5, "Faec" 0.4±0.5), and in the faecal plots in the morning ("Decid" 0.8±0.5, "Faec" 2.0±1.4). – Of course, migrations may also occur in small, slowly moving species, but these can not be detected in the scale of this experiment.

The community composition in the five main plots (blocks) differed from each other; the block effect was significant in as many as 8 species (*table* 3). Thus, despite the markedly constant structure in a large ("global") scale (see above), in a smaller scale (comparable to "gradients" by Usher, 1976) the populations were unevenly distributed. In a still smaller scale (24 x 32 cm) Usher (1976) reported that Mesostigmata show less tendency to aggregation than do Collembola and Oribatida. The matter of scale is one of the most questioned topics in population and community ecology (Begon *et al.*, 1990), and should be considered e.g. when planning a sampling design.

Total community

Canonical correspondence analysis reveals a distinct pattern in the community of Mesostigmata in relation to the treatments (*fig.* 1). The litter plots ("Conif"

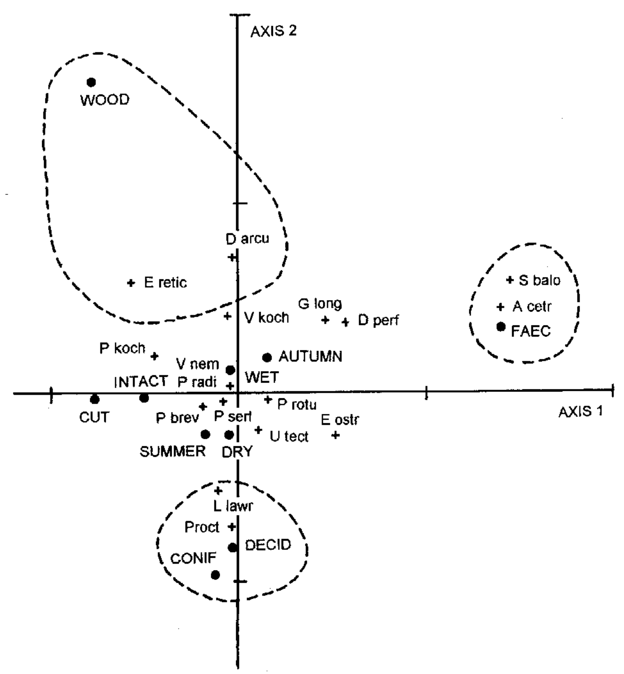

Figure 1. – Result of CCA analysis showing the distribution of 17 most abundant species (+) in a biplot with respect to treatments, season and "weather" (● = centroids of the "environmental" variables).

and "Decid") are located close to each other, and the species *L. lawrencei* and *Proctolaelaps* sp. are related to this "litter cluster". This is remarkable since these two types of litter are dissimilar as resources for decomposer organisms (Swift *et al.*, 1979). "Wood" and "Faec" are both in opposite directions from the litter treatments. *A. cetratus* and *S. baloghi* are located close to "Faec", while no species shows close relation to "Wood". The remaining species, treatments, season and weather show no obvious pattern. Monte carlo permutation test reveals that the probability is low ($P=0.01$) that the eigenvalue could be obtained by random arrangement of species with respect to the selected variables.

CONCLUSIONS

1. The community of predatory mites differs between different habitat patches of the forest floor:

a) Some species are more abundant in patches with high litter input, but spruce and birch litter harbour similar communities despite their dissimilarity as resources for decomposers.

b) There is no specialised community of fresh dung inside a forest. Several species are more abundant in patches with (aged) faecal material, but most of these are common forest dwellers. However the total community differs significantly from other kinds of patches.

c) Patches with field vegetation cut or with old rotten wood under humified soil and mosses only harbour an impoverished "forest community".

2. Large, active predators may perform horizontal migrations between patches (in a scale of ± 1 m^2) in relation to time of day or prevailing weather.

3. The community and populations are quite constant "globally", in a scale of 100 km, but there are "gradients" in a scale of 50 to 100 m.

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